ENGINEERING CASE LIBRARY

ECL 202

MANURE DISPOSAL WITH ELECTRO-HYDRAULIC CONTROLS

A young engineer designs the control circuit required to automate the disposal of manure in a dairy farm. He uses available components selected from catalogs.

 Written by Brian Foord. Published with support from the sponsors of the ASEE-Stanford Engineering Case Program:

E. I. du Pont de Nemours and Company
The General Electric Foundation
IBM
Olin Corporation Charitable Trust
Union Carbide Corporation

In 1972 I worked for Sweetland Company of San Leandro, California, as a sales engineer and was a full-time student in mechanical engineering at California State University at Fresno.

During a sales call in March, a bearing distributor who distributes hydraulic and pneumatic products, asked me how I would sequence a series of compressed air cylinders. We discussed the cycle times of the cylinders and concluded that due to the extended time between cycles, the use of pneumatic logic or compressed air timers was impractical, and the use of slow speed cams activating compressed-air valves, sequencing the cylinders, was probably the best solution.

The following month while calling on Teisinger & Son Hydraulics, the question was posed as to how to sequence a series of hydraulic cylinders which happened to have the same cycle times as those air cylinders discussed at the bearing company. I recommended a set of cams and air valves if the use of pneumatics was feasible; but, if not,a power unit and electrically operated hydraulic valves were available from Sweetland Company, and the cams, limit switches and drives were recommended from other distributors.

In June, I went to work for Teisinger & Son Hydraulics. They had just received an order from Foster Farms of Livingston, California, on a job which had been bid to sequence a series of hydraulic cylinders. My first assignment at Teisinger & Son was to order the hydraulic components I had recommended the previous month (the time clock, cams, and drives had already been purchased), construct the entire control system in a water-tight enclosure, and do the initial jobsite start-up. The customer was doing the piping and electrical connections from the enclosure.

I had obtained my mechanical, electrical, and hydraulic design experience while working for four years as design engineer for a custom agricultural machinery manufacturer. Pneumatic and fluidic experience had been gained during the two years I represented Sweetland Company in the Fresno area.

The original problem statement of the Foster Farms job was to sequence nine hydraulic cylinders in turn to allow pumped water to flush manure from under chicken cages. The hydraulic cylinders were to open water gates, allowing water to flush down cemented canals and empty into a lake. At least one gate was to be open while the water pump was running. If the water pump was to start with a failure in the control circuit, all of the gates were to be forced open by the water pressure. Gates were to stay open for up to five minutes

and the next gate in sequence was to open before the previously opened gate closed. All gates were to be sequenced and then the pumps were to stop. This sequence was to cycle every four hours, twenty-four hours a day.

The water gates were to be built and installed by the customer (Exhibit 1). They were simply pieces of pipe with a frame welded to them to support and guide a cap which could be lowered onto the end of the pipe to stop the water flow. The other end of the pipe was connected to a branch of the main water pipe coming from the water pump. Two and one-half inch diameter hydraulic cylinders (linear actuators) supplied by the customer were used to supply the force to hold the caps in place against water pressure when the gates were closed. The hydraulic cylinders were retracted by directing pressurized oil to the bottom side of the cylinder piston. This opened the gate, allowing water onto the concrete ways. The gate was closed, stopping water flow, and held closed by directing oil to the top of the cylinder piston and allowing the oil on the bottom of the piston to return to the oil reservoir.

Four-way solenoid-operated hydraulic valves were used to direct the pressurized oil to the cylinders. The valve solenoids shifted the valve to open or close the gate and were controlled by single-pole double-throw limit switches. The switches were operated by nine cams on a common shaft. (Exhibit 2) The cams were rotated by a 1/15th horsepower AC/DC gear motor (Exhibit 3), through a 50:1 worm gear speed reducer. With the requirement that a gate be open for five minutes, the controlling cams would have a speed of approximately one revolution in 45 minutes to sequence all nine gates.

An electronic motor speed control (Exhibit 4) was used to give a motor speed of from zero to approximately nine revolutions per minute. By going through the 50:1 speed reducer, a cam speed of approximately ten revolutions per hour was obtained. A 24-hour time clock (Exhibit 4) was used to supply electrical power to the AC/DC motor and speed control, solenoid limit switches, and motor starters of the water pump motor and hydraulic power unit motor. The clock was programmed with adjustable trips to supply electrical power for 15 minutes, once every four hours.

The pump was a 1-1/2 gallon per minute pressure-compensated, variable-volume piston pump (Exhibit 5). Variable-volume, pressure-compensated means that when this pump is deadheaded and the set pressure is reached, the pump automatically

strokes its volume back to flow only enough oil to maintain the set pressure and make up leakage which drains from the valves and cylinders to the reservoir.

Two-position, open-center, single-solenoid hydraulic valves (Exhibit 6) were originally installed so that when the solenoid was activated, the gate would open, and when the solenoid was not activated, the valves directed oil to hold the gate closed. Then, if the water pump was turned on without the oil pump being on, the water pressure would raise the gates by forcing the cylinder piston up, pushing oil through the pump to the reservoir. The hydraulic power unit would be the highest point in the system so the oil would not drain from the cylinders through the pump to the reservoir when the pump was off.

The components were mounted, wired, and plumbed in a 36" x 30" x 8" NEMA Type 4 enclosure. The cams were adjusted to sequence all nine gates in one revolution with the next gate opening before the open gate closed. The system was operated in the shop with pressure gages representing hydraulic cylinders.

It took approximately four days to mount all of the parts, do the wiring and plumbing, set the cams and test the system. The hydraulic power unit and completed enclosure were delivered to the customer by Teisinger & Son in July, and at that time, it was learned that the system was actually going to be used on a dairy farm instead of a chicken ranch. It was also learned that this new system was for the purpose of alleviating the problems which the large dairy farms have always had with collection and disposal of manure. The narrow, fenced pathways and feeding stalls made the collection difficult and the areas which were not easily accessible by bucket loader and hand shovel became breeding grounds for disease-carrying flies.

At the customer's dairy, the pathways and feeding stalls were concrete with four-inch high borders forming canals. These canals were sloped toward a pond with water, introduced at the highest point of the canals, flushing the manure into the pond.

The introduction of water onto the canals is controlled by the water gates. The water used for flushing is pumped from the pond using a 16-inch pump. When the pond begins to fill with sediment from the flushings, the sediment is pumped onto the banks of the pond for drying, and is then recycled for use as fertilizer for growing cattle feed. A flock of ducks controls algae and insects in the

ponding area. The pump is connected to the control gates by nine-inch plastic pipe and while the pump is operating, at least one gate must remain open to keep from over-pressurizing the pipe.

On previous installations, electric motors were used as gate actuators. These proved unsatisfactory due to the constant exposure to water and weather, and the danger of electrocuted cows from a short-circuited motor, since all the fencing and stalls are constructed with steel pipe. The hydraulic cylinders avoid the shock hazard and are unaffected by the weather and moist conditions.

The customer did not have the cylinders and power unit piped until September when, for the first time, I went to the jobsite for start-up. The power unit had been located a few inches off the ground on a concrete slab (Exhibit 7). The hydraulic lines went from the hydraulic control system to about eight feet above the ground, over and down to the cylinders located two feet above the ground. It took 1,800 feet of one-half inch pipe to connect the cylinders to the control panel.

Eight-foot high standpipes had been installed in the water system as an extra precaution to avoid over-pressurization of the plastic pipes. Too frequent use of the standpipes to relieve the pressure could still fail the plastic pipe.

On the initial start-up, the system worked fine until the time clock stopped the pumps after completion of the first cycle. During the fraction of a second it took to stop the water pump, the open cylinder clamped shut, which forced water out of the water standpipe. When the time clock opened the electrical circuit, it is thought that the solenoid probably released, shifting the valve before the hydraulic pump had fully stopped. The pressurized oil theoretically would then close the open gate. When the hydraulic pump stopped, the oil drained back from the pipes higher than the reservoir, turning the hydraulic pump and motor backward and overflowing the four-gallon reservoir.

I interchanged the hose connections on the cylinders and reversed the electrical leads on the limit switches (Exhibit 8) so that when the solenoids were activated, the gates would close and when not activated, would open. With this connection the system again worked fine until the time clock opened the circuit. Then the open cylinder closed, forcing water out of the standpipe. The oil drained back through the

pump, overflowing the tank again. A check valve could have been placed in the pump line to keep the oil from gravity feeding back to the tank, but this would not have helped the main problem of the open water gate closing. It was then realized that the great amount of pressurized oil flowing back to the tank through the small passages in the common manifold (Exhibit 9) must have been causing a back pressure which, when the solenoid released and the valve shifted this pressurized oil, forced the open gate closed.

Spring-centered, three-position, double-solenoid valves (Exhibit 6) were then ordered. With the three-position valves, one solenoid is powered to open the gates. To close the gates, that solenoid is released and the other solenoid is powered. When the electrical circuit is opened the valves center, blocking both cylinder ports, which then keeps the open cylinder open. When these valves arrived a week later, I installed them and rewired the solenoids to the limit switches (Exhibit 10).

The system has worked reliably to date, March 1973. Three valves have failed so far: in one, the valve spool was sticking due to dirt; the other two valves were said to have failed due to the swelling of a plastic guide supporting the armature of the coil. This caused the solenoid to stick in the activated position.

The customer is very happy with the system and the exact reason for the failures is still being investigated.

The complete control system sold for $2,800.

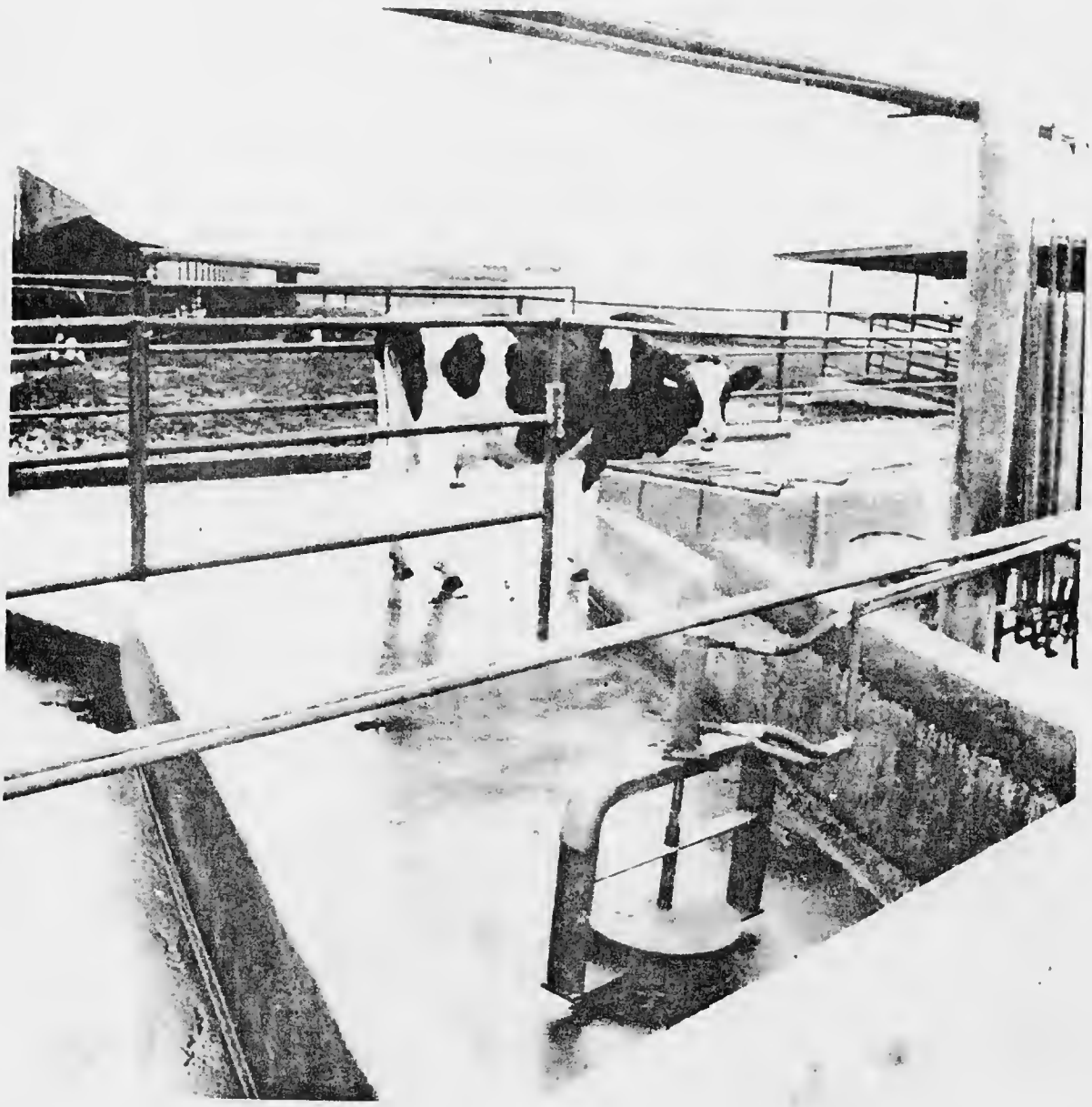


EXHIBIT 1

SUGGESTED QUESTIONS

1. With the compensator on the pump set at 800 PSI, what force does the cylinder exert?

2. If the water gate cap is 9 inches in diameter, what water pressure would just start to raise the water gate lid against the cylinder force at 800 PSI?

3. With the 1800 feet of Schedule 40 pipe to connect the nine cylinders to the control panel, how much oil is stored in the total pipe at zero PSIG?

4. With the control system as it is now working, what problems can you foresee when the ambient temperature rises?

5. If, at the end of the last cycle four hours ago, the ambient temperature was 70° F. and now the ambient temperature is 100° F., what is the pressure in the pipes if four hours ago the pressure was 800 PSI and the oil (SAE 10) then and now is the same as the ambient temperature. Consider no leakage from valves or cylinders.

6. What must have been the pressure in the water system to run water out of the eight foot high standpipe?

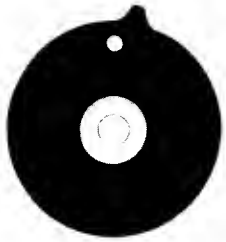
7. Design a pneumatic logic or fluidic system without cams to replace this present system.

8. Design a relay logic or solid state logic modules system to replace this present system.

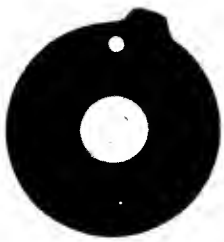
9. What is wrong with the system and how would you make it better?

Clippard PROGRAMER CAMS

ECL 202

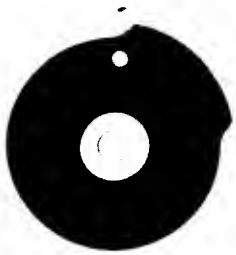


C33 - 15
(15° lobe)

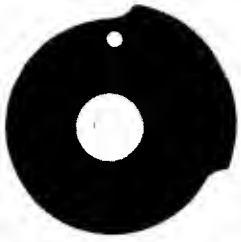


C33 - 30
(30° lobe)

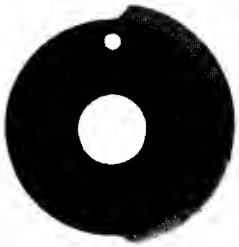
C33 - 60
(60° lobe)



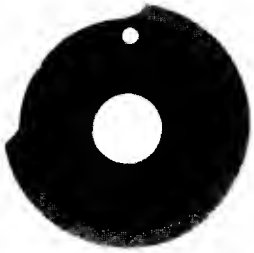
C33 - 90
(90° lobe)



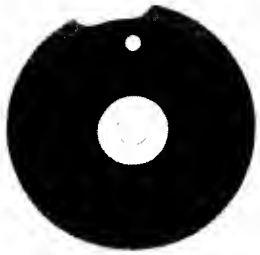
C33 - 120
(120° lobe)



C33 - 180
(180° lobe)



C33 - 270
(270° lobe)



C33 - 340
(340° lobe)

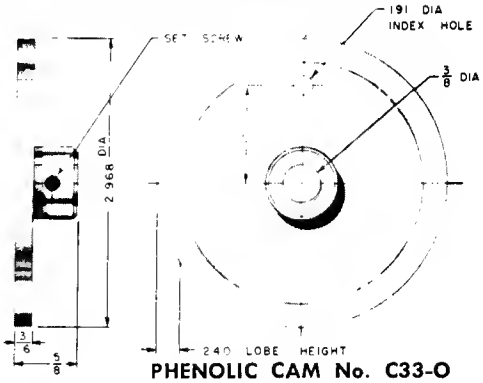
Note: Degrees of cam lobe denotes approximate ON TIME using Clippard No. 11925 Cam Follower Head

Cams are made of duroble, extra long lasting one piece phenolic moteriol, with o cadmium plated brass center hub. Each cam is quickly odjusted on progromer shoft with a single 10-32 screw with a nylon tip in the hub. 3⁄16" index holes ore provided at 0° position for reference and positive positioning. Initiol olignment of coms can easily be accomplished by inserting a 3⁄16" rod through these index holes in cams and end plates of unit. The eight standord cams shown obove will fit the majority of requirements but special cuts can be supplied.

When ordering Programer Units, specify any combinotion of blonk or standard coms (by part number) os shown obove.

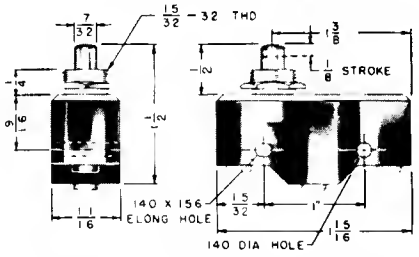
Should special cuts be needed, they are ovailable at nominal cost. Just send us a rough sketch of your requirements drown on a 3" diometer circle.

Uncut blank cams, No. C33-O, may be ordered for your own mochining if preferred. Cams may be easily mochined with on end-mill, saw, or belt sander, and touched up with a file.



PHENOLIC CAM No. C33-O

Single Pole, Double Throw
ELECTRICAL SWITCH Model ES-1



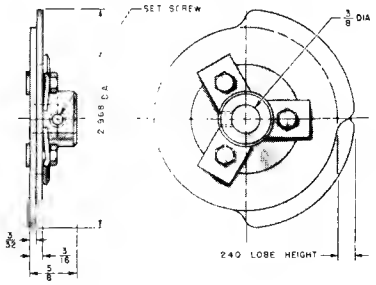
Moximum roting: 15 omperes ot 120, 240 or 480 volts AC; 0.5 amperes ot 125 volts DC; 0.25 omperes ot 250 volts DC.

ADJUSTABLE CAMS

The adjustable Cam is produced in five sizes: A33-30, 45, 70, 120 and 210

A33-30 permits adjustment from 30° to 50°
A33-45 permits odjustment from 45° to 80°
A33-70 permits adjustment from 70° to 130°
A33-120 permits adjustment from 120° to 230°
A33-210 permits adjustment from 210° to 360°

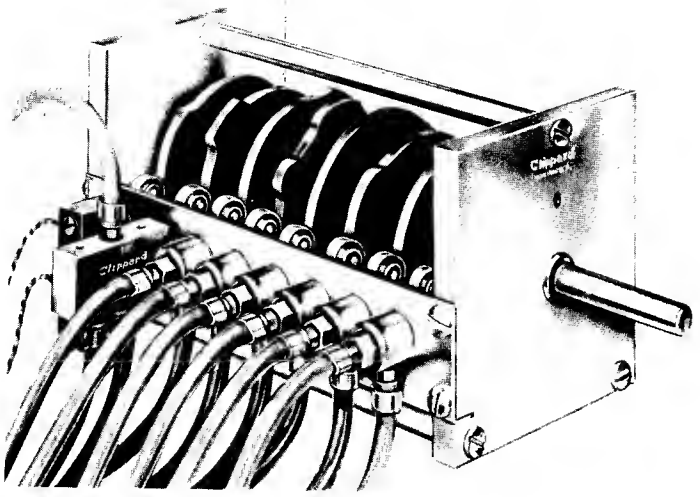
Loosen the three center screws, rotate to desired point and tighten. These ore porticularly useful where it is difficult to pin point the exact requirements or where o circuit is necessary when other factors involved vary. It is, of course, olso useful in prototype ossemblies.



Clippard PROGRAMER ACCESSORIES

Accessories listed are engineered ta moke the Clippord Sequence Progrommer the most flexible ond useful unit on the market. They ore used in conjunction with the com Follower Heod No. 11925 (Page 12). It fits over the threoded shoulders of the valves ar switches ond is secured in place with lock woshers.

Clippard MINIMATIC SEQUENCE PROGRAMER • MSP ECL 202



CONSTRUCTION FEATURES

1. Self-Lubricating Bearings.
2. ⅜" Steel Shaft, Extendible out Either ar Both ends for Tandem Operatian.
3. 1-Piece Phenalic Cams — Long Lasting, Easily Machined.
4. Cams easily adjusted on shaft with one set screw.
5. Units accammodate 4 ta 14 cams.
6. Mounting brackets Accommodate 4 to 14 Clippard Cam Follawers and Air Valves, or Electrical Switches.
7. End plates Tapped for Maunting Bottam ar Rear.
8. Positive Cam Indexing assured thru Alignment Holes in Cams and End Blacks.
9. End Blocks Heavy Aluminum.
10. Rigid Channel Steel Mounting Bracket for Valves or Switches.

FOR PRECISE TIMING AND CYCLING OF . . .

AUTOMATIC WORK OPERATIONS with AIR OR ELECTRICITY

CONTROLS FEEDING DEVICES, AUTOMATION EQUIPMENT, PACKAGING MACHINERY, ETC. — FOR CONTROLLING OR PERFORMING THOUSANDS OF AUTOMATIC WORK FUNCTIONS.

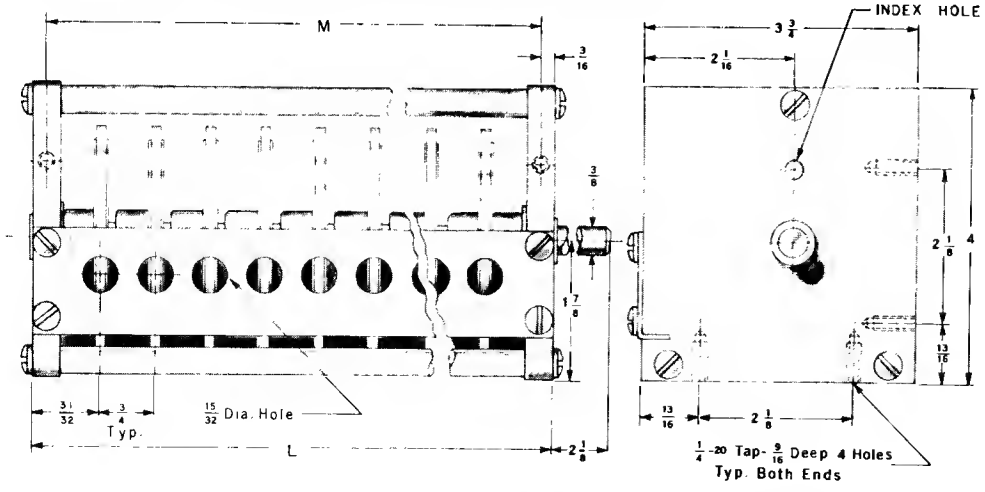
Clippard Sequence Programers may be powered directly from the machine they contral, or by any small geared-dawn matar. Carrect direction of rotation may be observed by driving unit from either end. Shafts may be caupled tagether for tandem aperation.

Clippard Programers operate up to fourteen Clippard standard two-way, three-way, or four-way valves with cam fallawers Na. 11925 and are suitable far use with many small snap actian type switches such as Clippard ES-1. Valves on this unit may cantral large pilot aperated valves, or be connected directly to cylinders, eliminating castly switches and solenaid valves. An excellent device far operating in explosive atmospheres.

Cams far this unit are of salid one-piece phenolic material that will last almast indefinitely and can never get out af adjustment. A selectian af eight standard cam cuts (shown an the oppasite page) is available to fill over 90% af requirements. Special cuts, according to your sketches may be supplied at naminal cost, or inexpensive cam blanks furnished for yaur own machining if desired. Initial alignment of cams can easily be accomplished by inserting a 3/16" rad thraugh the indexing holes (reference hales) in unit and cams. Individual cams are quickly adjusted on programer shaft, with a single set screw in the hub. Once aligned and set screws tightened, the sequence is permanently fixed.

For the mast effective use of this unit, specify Clippard Minimatic Valves, Electrical Switch and Cylinders.

RECOMMENDED TORQUE: Approx. 2 inch-pounds per cam.

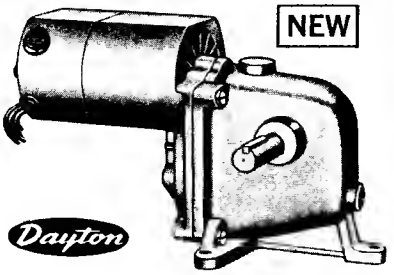


MODEL NO.	"L" DIMENSION	"M" DIMENSION
MSP-4 (4 Cams)	4 5/32"	3 25/32"
MSP-6 (6 Cams)	5 21/32"	5 9/32"
MSP-8 (8 Cams)	7 5/32"	6 25/32"
MSP-10 (10 Cams)	8 21/32"	8 9/32"
MSP-12 (12 Cams)	10 5/32"	9 25/32"
MSP-14 (14 Cams)	11 21/32"	11 9/32"

THE LIST PRICE OF THESE UNITS INCLUDES VALVE MOUNTING BRACKETS, CAMS - STANDARD CUT, OR BLANK - PLUS ALLEN WRENCH

1/15 HP, AC/DC RIGHT-ANGLE GEARMOTORS

2.8 to 100 RPM, F/L. 115V. Single and Double Shaft Models. External Brush Caps

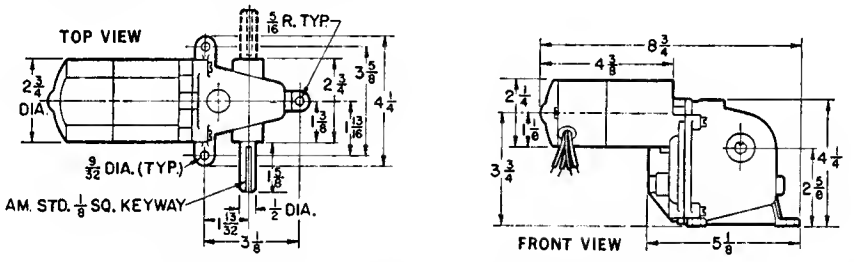


$25.53 Lots 6, Up

High starting torque, Dayton gearhead motors. Powered by 1/15 HP, 5000 RPM, F/L speed, 115V, AC/DC, series-wound, motor. Has ¼ x ¼ shunted brushes with external brush caps that permit easy replacement and provides improved brush life (approx. 700 hours). Output speed varies with load (decreasing with increasing load, etc.)—this must be considered when applying. Speed is adjustable by means of variable autotransformer or rheostat. Motor integral part of gear unit for optimum gear/bearing alignment. Rotation electrically reversible by external reconnection—four 18" #18 AWG leads provided. Triple reduction, precision-cut gears, totally enclosed in grease-packed, rigid, die-cast housing; phenolic first stage gear for reduced noise. Unit suitable for all-position mounting. Right angle drive. Hardened output shaft 1½" x ½" dia. with Woodruff key (No. 3M238 has double shafts 1½" x ½" dia. with Woodruff key; otherwise same as No. 3M237). Gray enamel finish. Shpg. wt. 6 lbs.

Full Load Speed RPM	No Load* Speed RPM	Full Load Cont. Torque Inch-Lbs.	Ratio	Shaft Ext.	Shaft Ht.	H	W	D	Stock No.	Retail	Each	Lots 6
2.8	9	450	1787:1	Single	2 5/8	4 7/8	8¾	4¼	**3M234**	$40.31	**$26.87**	**$25.53**
6.7	24	162	745:1	Single	2 5/8	4 7/8	8¾	4¼	**3M235**	40.31	**26.87**	**25.53**
12.8	37	110	390:1	Single	2 5/8	4 7/8	8¾	4¼	**3M236**	40.31	**26.87**	**25.53**
21.0	66	100	238:1	Single	2 5/8	4 7/8	8¾	4¼	**3M237**	40.31	**26.87**	**25.53**
21.0	66	100	238:1	Double	2 5/8	4 7/8	8¾	4¼	**3M238**	41.64	**27.76**	**26.37**
50.0	176	45	100:1	Single	2 5/8	4 7/8	8¾	4¼	**3M239**	40.31	**26.87**	**25.53**
100.0	306	27	52:1	Single	2 5/8	4 7/8	8¾	4¼	**3M240**	40.31	**26.87**	**25.53**

(*) No-Load speed is approximate and will vary unit-to-unit.



REPLACEMENT PARTS FOR ABOVE GEARMOTORS

INPUT MOTOR, 115V, AC-DC, 5000 RPM. Wt. 3 lbs. **No. 2M157.** Retail $12.26. Each.....**$8.17**

BRUSH KIT FOR NO. 2M157.
¼x¼" shunted brushes with springs. Pkg. of 12. Wt. 1 oz. **No. 1R211.** Retail $4.50. Each **$2.98**

COMPLETE ARMATURE for No. 2M087 & 2M157. Wt. 9 oz. **No. 1R204.** Retail $5.55. Each.....**$3.70**

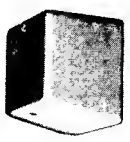
CARBON BRUSHES for No. 2M087, Pkg. of 12. Wt. 1 oz. **No. 1R205.** Retail $1.50. Pkg. of 12....**$1.00**

COIL SPRINGS for No. 1R205 brushes, Pkg. of 12. Wt. 1 oz. **No. 1R206.** Retail $0.54. Pkg. of 12....**$0.36**

ELECTRONIC SPEED CONTROL FOR ABOVE MOTOR

Turn of dial permits constant torque and variable-speed from 0 to 80% of full-load speed of AC-DC gearmotors listed above. Dial sets speed desired, electronic feed-back maintains speed, increasing voltage to motor as load increases. Two models available, No. 4X796, 5 amp; and No. 4X797, 10 amp, 115V. See Index under "Controls, Speed."

COVER FOR DAYTON SHADED POLE GEARMOTORS



Protects motors on all Fig. A, 1 to 50 RPM shaded pole gearmotors (No. 3M095, 3M096, 3M097, 3M099, 3M100 & 3M101 listed on nearby page) against dust, grease and other foreign matter. Made of industrial gray fiberglass that withstands a temp. of 300°F. max. Cover also adds to general appearance and is easily attached with screws furnished. Shpg. wt. 4 oz.

Motor covers are optional for motors on intermittent duty applications, only. **Motor warranty void if cover is used on continuous-duty.**

No. 3M151. Retail $1.25. Each **83c**; lots 6.....**78c**

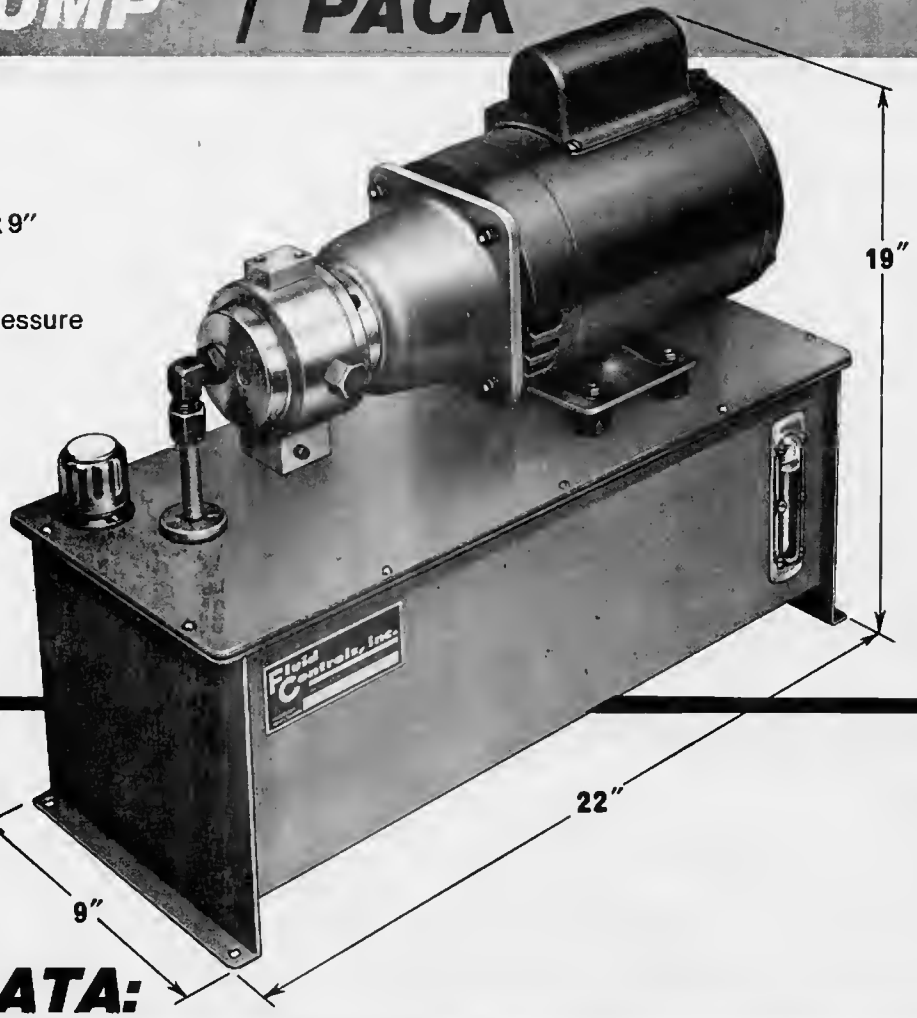
EXHIBIT 3

ECL 202

NEW! ···POWER-ONE···

FROM FIELD CONTROLS, INC.

PRESSURE COMPENSATED PISTON PUMP / POWER PACK



FEATURES:

Compact — Saves space
Entire power pack only 22″ x 19″ x 9″

Efficient
Low heat build up when holding pressure (35°F. over ambient maximum)

Versatile — Unique one H.P. concept
Just plug into any 115 AC outlet and go!

Quiet — Ideal for any use
60 to 70 DB (A) @ 1000 PSI
9.2 to 19.6 sones maximum

Specially designed to fit your one horsepower needs — Available off-the-shelf

ENGINEERING DATA:

PRESSURE
1000 PSI maximum
Cutoff adjustable 250-1000 PSI

FLOW
1½ GPM @ 1800 RPM
(.2 cubic inches/revolution)

FLUID
Good quality hydraulic oil
100-200 SSU @ 100°F.
Operating temperature maximum @ 180°F.

FILTRATION
25 micron system filtration recommended
100 mesh suction strainer provided with power unit

PORT SIZES
Inlet—8 SAE
Outlet—6 SAE
Case drain—⅛″ NPTF

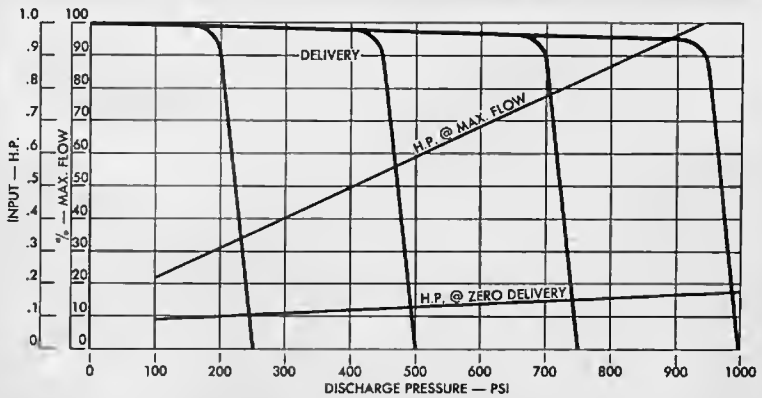
INLET CONDITIONS
6″ mercury
(3 PSI) maximum vacuum at pump inlet

CASE PRESSURE
5 PSI, maximum

RESPONSE TIME
15 milliseconds on-line to deadhead
40 milliseconds deadhead to on-line full flow

EXHIBIT 5

TYPICAL PUMP PERFORMANCE



SUGGESTED APPLICATIONS:

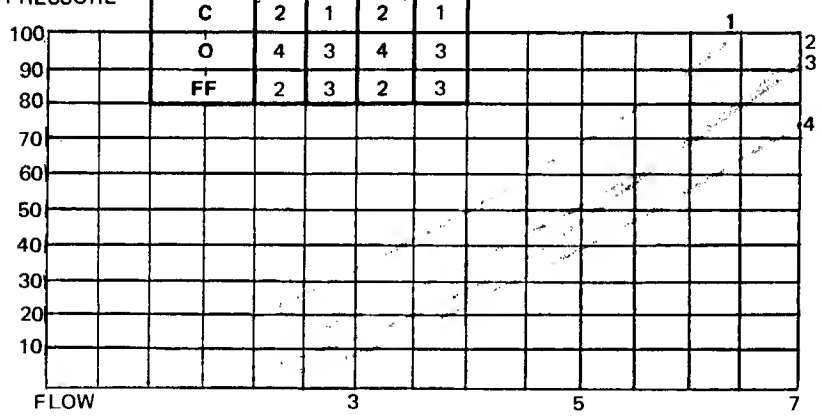
Can replace air-oil, electrical, and mechanical systems on Automated Equipment—Industrial Machinery—Servo Systems—Clamping—Paper Processing—Textile Equipment—Medical Equipment or your special machinery.

PERFORMANCE

Nominal Flow Capacity	5 GPM
Maximum Flow without Malfunction	See Table Below
Maximum Operating Pressure	3000 PSI
Maximum Tank Port Pressure	3000 PSI, Static 1000 PSI, Operating
Application Recommendations	
Filtration	75 - 600 SSU
Viscosity	25 Micron
Fluid Temperature	0 - 140°F
Maximum Cycles per Minute	90
Response Time:	
Solenoid Energizing	
AC	.016 Second
DC	.100 Second
Spring Centering	.010 Second
Spring Offset	.030 Second
Weight:	
Double Solenoid	3-1/2 lbs.
Single Solenoid	3 lbs.

PRESSURE DROP

SPOOL	P-A	B-T	P-B	A-T
C	2	1	2	1
O	4	3	4	3
FF	2	3	2	3



MALFUNCTION FLOW (AC SOLENOIDS)

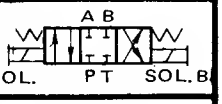
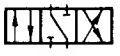
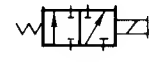
SERIES		QF AND QM SERIES				QG AND QJ SERIES
SPOOLS		C	O	FF	OP1	C
3-WAY CIRCUITS	1000 PSI	9	7	7	7	9
	2000 PSI	9	7	5	7	9*
	3000 PSI	9	7	5***	7	5**
4-WAY CIRUCITS	1000 PSI	9	7	7	7	7
	2000 PSI	9	7	7	7	7
	3000 PSI	9	7	5	7	7

*5 GPM with 'A' port blocked.
**3 GPM with 'A' port blocked.
***3 GPM with either cylinder port blocked.

Data based on fluid at 100 SSU at 100°F.

Figures in malfunction flow chart are approximate maximum flows at which a typical valve will continue to function. Failure to shift or erratic shifting may occur at higher flows due to insufficient solenoid or spring return force. Consult factory for data on other spools.

SPOOLS

APPLICATION	TYPE	GRAPHIC SYMBOLS
THREE POSITION QF-005	C	
	O	
	FF	
	F1	
	FO1	
	OP	
	OP1	
	FFX	
	TT	
TWO POSITION DETENT QM-005	C	
	O	
SPRING OFFSET SOL. A QG-005	C	
	P	
SPRING OFFSET SOL. B QJ-005	C	
	P	

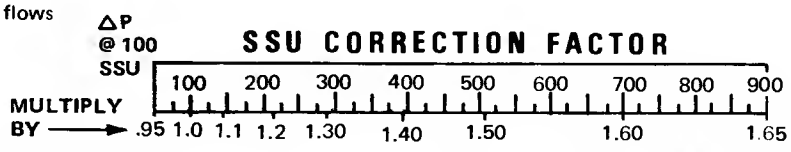


EXHIBIT 7

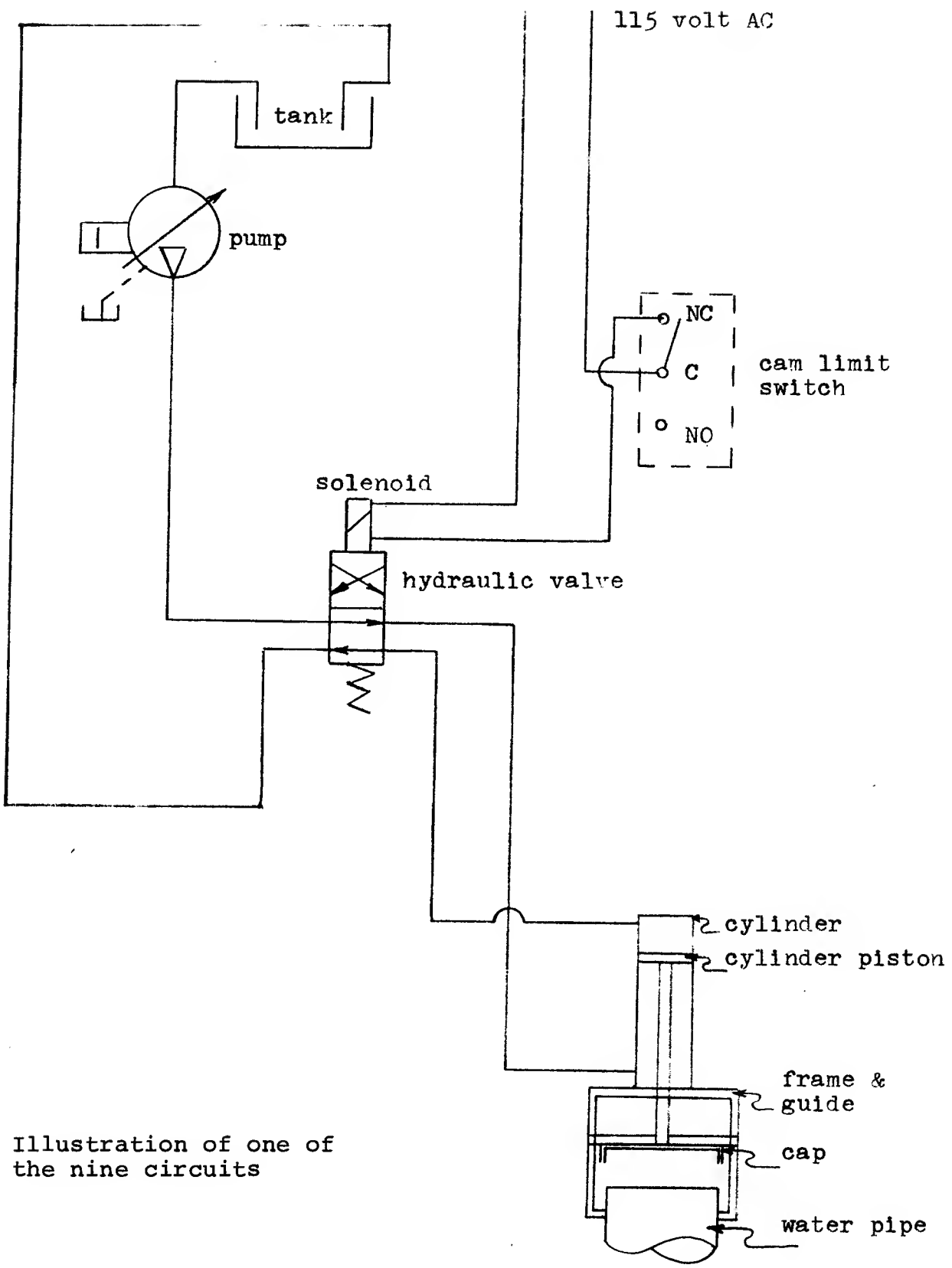


Illustration of one of the nine circuits

EXHIBIT 8

subplate

P115-02-*

- P115 - For Standard Valve
- 02 - 1/4" NPTF
- NO SYMBOL - BACK PORT
  AB - SIDE and BACK PORTS

manifolds

CB*-P115-02-*-A1

- DESIGN SERIES
- A - Side Ports Only
  C - All Ports Out the Side plus Back P and T Ports
- 02 - 1/4" NPTF
- MOUNTING SURFACE for QF-005 SERIES VALVES
- CB2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12, Number of Directional Valve Stations

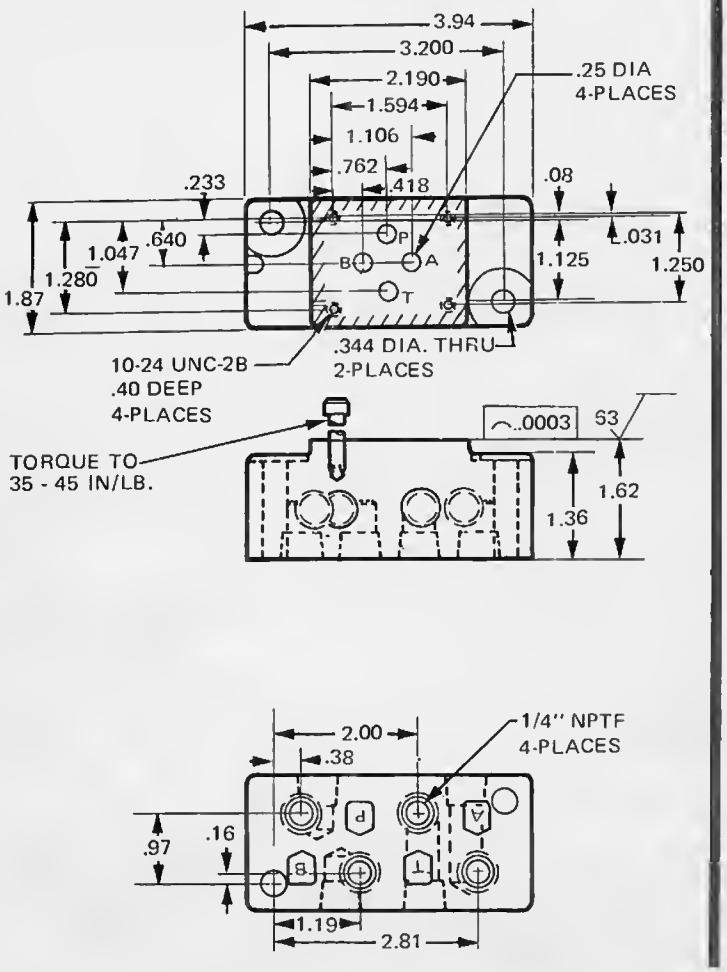
Double A spring centered and spring offset valves may be mounted in any position. Detented valves, however, should be mounted horizontally to prevent the possibility of spool shift caused by machine vibration during extended periods of solenoid inactivity.

When mounting a valve without a subplate or a manifold, a machined pad conforming to the shaded area (below) must be provided.

Weights:

Standard subplate 3 lbs.	CB7 . . . 21 lbs.
CB2 . . . . . 6 lbs.	CB8 . . . 24 lbs.
CB3 . . . . . 9 lbs.	CB9 . . . 27 lbs.
CB4 . . . . . 12 lbs.	CB10 . . . 30 lbs.
CB5 . . . . . 15 lbs.	CB11 . . . 33 lbs.
CB6 . . . . . 18 lbs.	CB12 . . . 36 lbs.

(SIDE PORTED SUBPLATE SHOWN IN)



Manifolds range in size from 2 to 12 stations and permit multiple circuit building with a minimum of installation time. Ask for dimensional and ordering information in 40-01541-02.

DIVISION OF
Brown & Sharpe Mfg. Co.

MFG. IN MANCHESTER, MICHIGAN 48158
HIGH WYCOMBE, BUCKS, ENGLAND

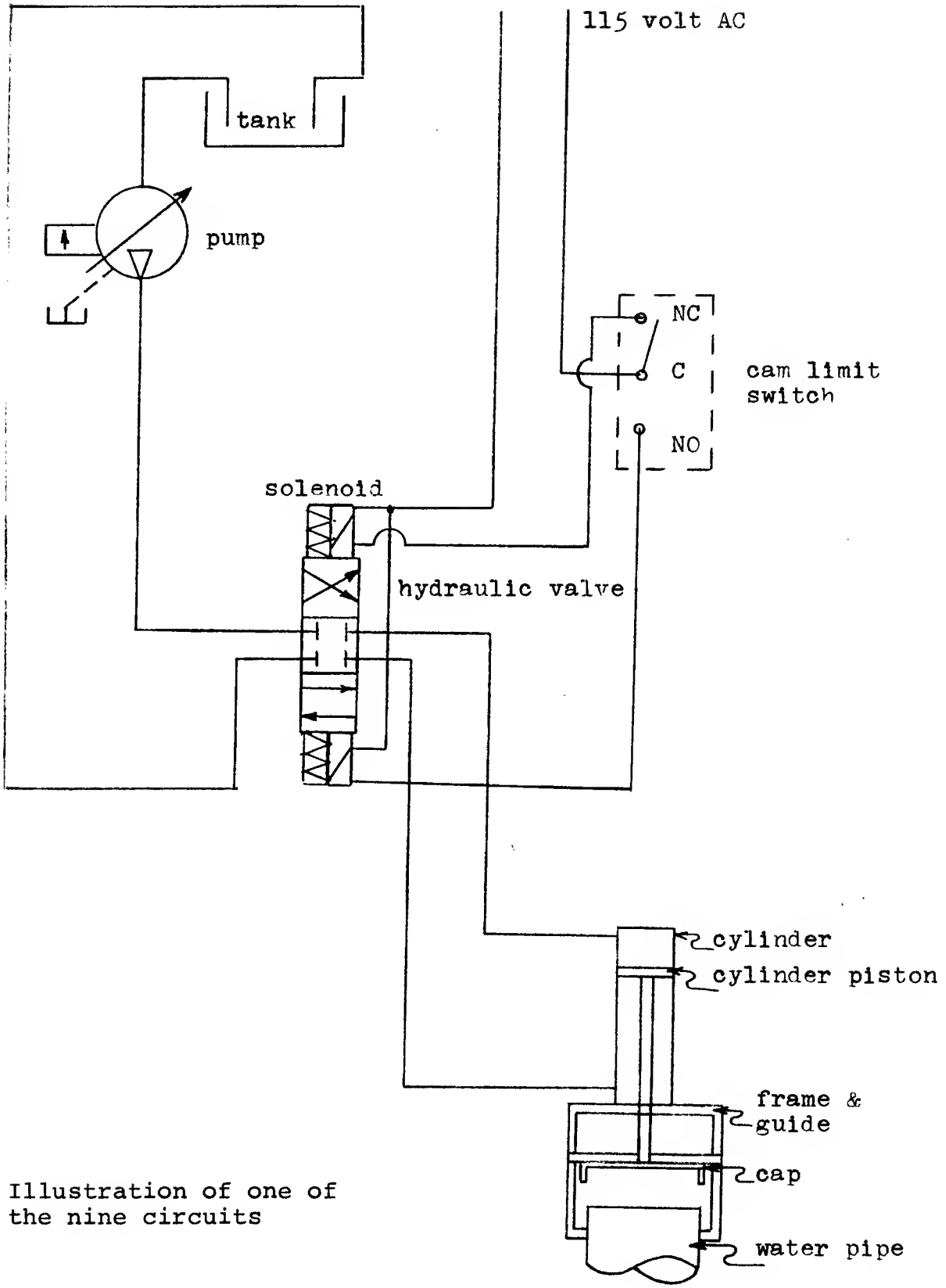


Illustration of one of the nine circuits

EXHIBIT 10

ELECTRONIC SPEED CONTROL

For AC-DC and Series DC Motors
Variable Speed with Constant Torque

Dayton **$8.44**
5 A. Lots 6

Turn of dial permits wide range of speed control from 0 to 80% of full speed of power tools, appliances, sewing machines, grinders, blowers, pumps, gearmotors, that are driven by AC-DC (Universal) brush-type motors. The variable speed is accomplished without loss of motor torque. Dial sets speed desired, electronic feed-back maintains speed increasing voltage to motor as load increases. Full speed obtained by rotating dial to extreme clockwise position. Two models available; 5 & 10 amp, 115V, which mount in panels or directly into standard "handy" boxes. 5 amp model uses existing single gang wall plate, 10 amp uses double gang plate (handy box and wall plate not included). Easy to install and operate, easy-to-follow instructions included. Shpg. wts. 4 and 9 oz. respectively.

QUANTITY & O.E.M. PRICES ON REQUEST

Amp.	Stock No.	Each	Lots 3	Lots 6	Lots 12
5	4X796	$9.10	—	$8.44	$7.79
10	4X797	16.05	$14.90	—	13.77

INDOOR-OUTDOOR 24-HOUR CONTROL

Operates in 15-Minute Increments for Flexible Schedule

$28.60 Controls traffic signals, commercial heating, poultry feeders, music systems and similar intermittently-operated equipment. 96 self-retaining trippers in 24-hour dial for 1 to 48 operations per day in multiples of 15 minute ON and OFF periods. Trippers programmed with touch of finger. Supplied with patented Skip-A-Day dial that permits omission of any day or days in week. SPDT isolated contacts for independent load circuit operation. Sealed, lifetime-lubricated, heavy-duty synchronous motor, 120V or 240V, AC. One control for either voltage. 10 Amp. 120V, 5 Amp. 208-240V; 125 VA pilot duty. Weather-resistant, breather-type, gray enameled case for indoor or outdoor use. Hasp for seal or padlock. 10 H x 5½ W x 4" D. U.L. & C.S.A. listed. Dayton brand. Shpg. wt. 6½ lbs.

No. 2E213. 24-Hour Control. Retail $44.00. Each..... **$28.60**

EXHIBIT 4